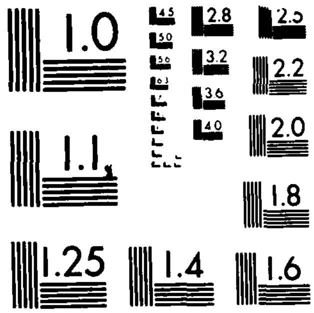
AD-A141 808 BOTTOM-MOUNTED PROFILING WINCH(U) WOODS HOLE OCEANOGRAPHIC INSTITUTION MA R G WALDEN ET AL. MAR 84 WHOI-84-12 N00014-82-C-0019

1/1

UNCLASSIFIED F/G 8/10 NL

END
DATE
FILMED
7-84
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(12)

WHOI-84-12

AD-A141 808

Woods Hole Oceanographic Institution

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

Bottom-Mounted Profiling Winch

by

R. G. Walden and C. W. Collins, Jr.

March 1984

Technical Report

Prepared for the Office of Naval Research under Contract N00014-82-C-0019.

Approved for public release; distribution unlimited.

84 06 05 089

WHOI-84-12

BOTTOM-MOUNTED PROFILING WINCH

by

R. G. Walden

and

C. W. Collins, Jr.

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

March 1984

TECHNICAL REPORT

Prepared for the Office of Naval Research under
Contract N00014-82-C-0019

Approved for Distribution: Robert C Spindel

Robert C. Spindel, Chairman
Department of Ocean Engineering

TABLE OF CONTENTS

ABSTRACT

A winch has been developed which can be free-dropped to the ocean bottom in full ocean depths. The winch is powered by self-contained batteries and can be programmed to cycle self-recording instruments from close to the bottom to 100 meters above the bottom continuously or in steps. A typical scenario is envisioned as one complete cycle per day for one year with the instruments pausing each five meters for two minutes while measurements of current, temperature and conductivity are made. The upper section of the tripod contains the winch and instrumentation and is recovered by sending an acoustic command to a release mechanism allowing it to come to the surface.

Bottom-Mounted Profiling Winch

INTRODUCTION

Current interest in observing oceanographic processes in the benthic zone in the deep ocean promoted the development of a bottom-mounted winch which can cycle internally recording instruments near the sea floor at preselected times and depth intervals. Glass spheres provide buoyancy for the instruments which are attached to a Kevlar line stored on the winch drum. This technique permits profiles of parameters such as current velocity, temperature and conductivity to be made.

A wide range of sampling scenarios including depth intervals, dwell periods and cycling times are possible consistent with the battery power available. The prototype discussed here can make more than 300 complete cycles to a height of 100 meters above the bottom.

1.0 GENERAL DESCRIPTION

The winch and its associated components are contained in an aluminum tripod structure which is free-dropped to the ocean bottom. The structure is made up of two sections. The lower section contains the battery power supply which also provides the weight necessary to anchor the system. The upper section contains the winch, control circuits and acoustic release. The winch drum contains 100 m of Kevlar line connected to internally recording instruments and glass spheres used for buoyancy. Six glass spheres are attached to the upper part of the tripod to provide buoyancy to return it to the surface after firing of the release. The winch control electronic circuitry is housed in a separate pressure case. Another pressure case contains a hydrophone, electronics and battery supply for the acoustic release. The mechanical portion of the release, separate from the electronics and in its own pressure case, acts as a link holding the top section of the tripod securely fastened to the lower section until released.

The batteries and winch motor and gear assembly are housed in fiberglass compartments filled with oil operating in pressure balance with the hydrostatic pressure permitting operation in full ocean depths.

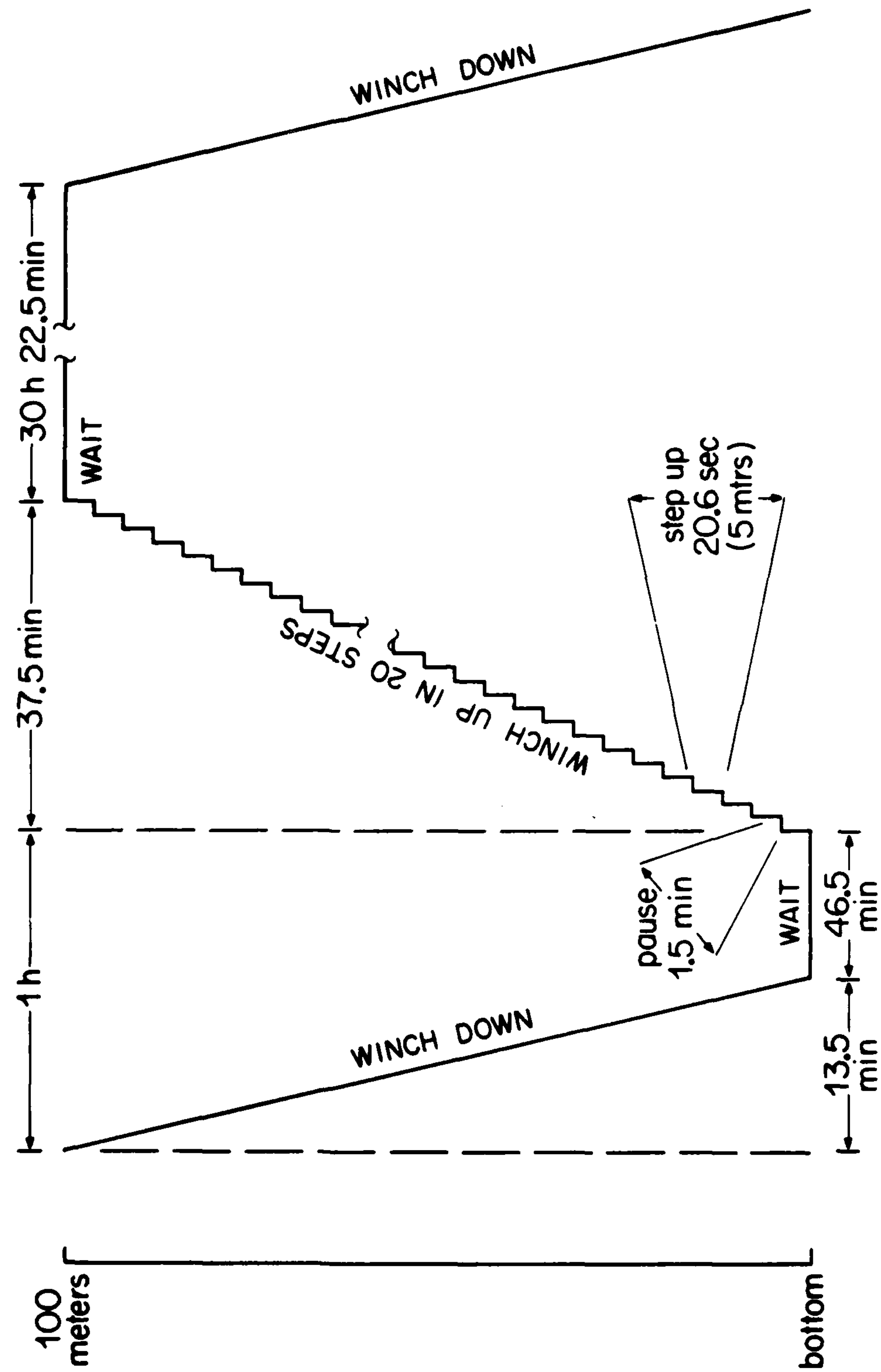
The winch can be programmed to unspool the line in steps, typically 10 meters, pause for two minutes while the instruments record data and then proceed to the next level. After reaching the required depth off bottom (maximum of 100 m) the direction is reversed bringing the recorders back to the bottom, but the programming is flexible, so that the total cycle or any part can be changed to fit the experiment requirements. Figure 1 shows a typical timing sequence.

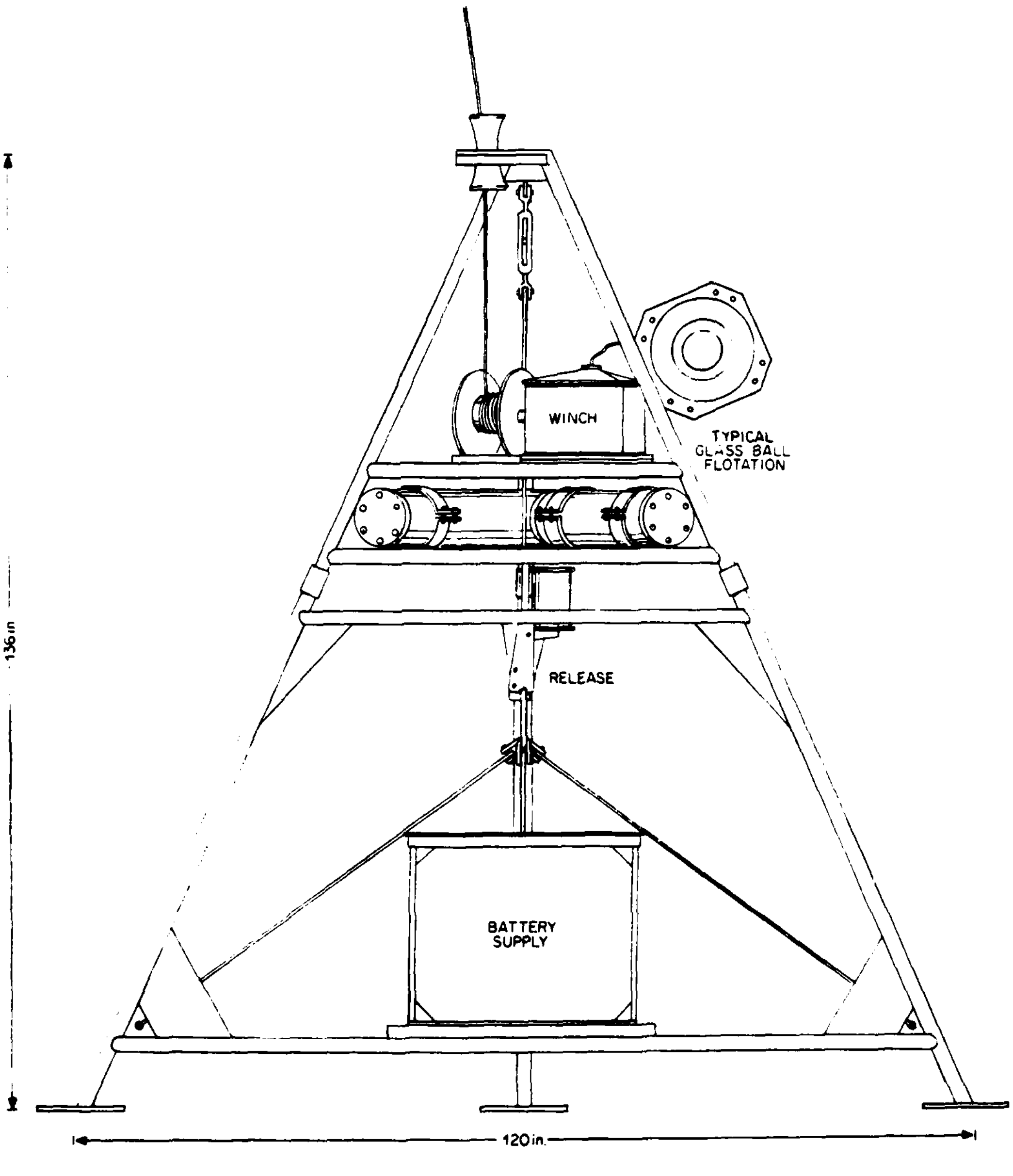
2.0 MECHANICAL

2.1 Frame

The tripod is constructed of one and one-half inch schedule 40 inch aluminum pipe as shown Figure 2. Twelve inch pads are welded to the

TYPICAL TIMING DIAGRAM





Winch Assembly

bottom of the legs to restrict penetration into the sediments. The frame is constructed in two sections, the section containing the battery power supply while the winch and control circuitry is located in the upper section. The two sections separate at the midpoint upon release, returning the upper section to the surface. Specially machined inserts in the pipe at the point of detachment shown in Figure 3 ensures proper alignment of the two halves when assembled yet permits reliable separation with no binding upon release. The two sections are held together by three 5/16 inch wire ropes fastened to the lower portion of each leg of the lower tripod section. The upper end of the cables attach to a ring which is held by the jaws of the acoustic release which in turn is fastened to the apex of the top tripod section. A turnbuckle allows the cables to be pre-tensioned. A large bell mouth constructed of fiberglass fairleads the Kevlar line from the winch drum.

The battery box and oil reservoir are fastened to cross-members attached to the bottom of the lower frame. The winch drum, motor and gear-box are fastened to cross-members on the upper tripod so that the winch drum is aligned directly under the bell mouth. The winch control circuitry and the acoustic release are in separate pressure cases mounted on the upper frame.

The total weight in air is 2900 pounds and 850 pounds in water including flotation.

2.2 Winch Assembly

The winch consists of a reversible electric motor, gear reducer and winch drum. The motor and gear reducer are mounted in a fiberglass compartment with the output shaft extending through the end of the compartment with a shaft seal. The compartment is filled with Bray oil 3M626-2 to maintain pressure equilibrium with the hydrostatic pressure. A bladder containing reserve oil and connected by hose to the compartment is mounted below the unit to provide a slight positive pressure to the oil inside. This compensates for the slight volume reduction of the oil due to the temperature and pressure experienced on the sea bottom.

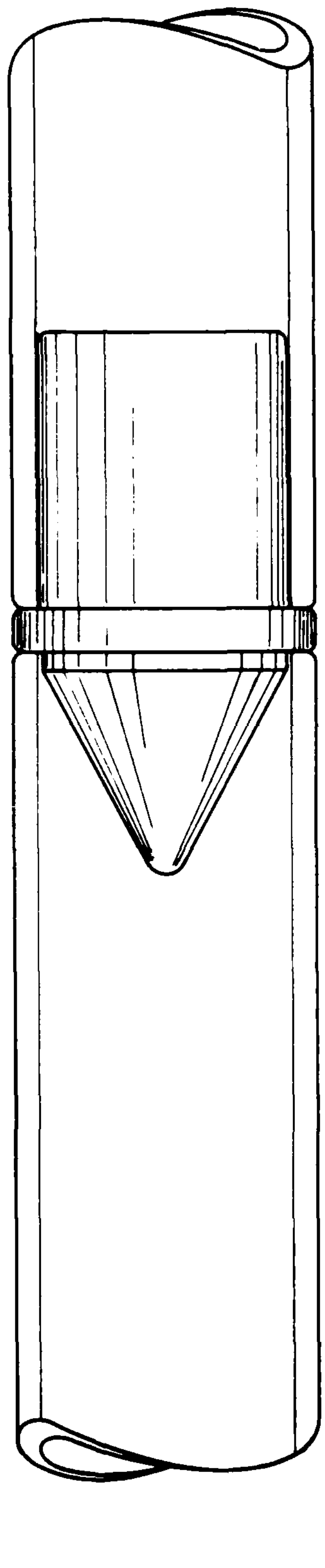
2.2.1 Motor

The electric motor is a Model 04-089 made by Inertial Motors Corporation modified to include outboard brushes, increased brush pressure and holes for oil flow. The motor runs well in this oil and is unaffected by the hydrostatic pressure. The motor characteristics at a typical operating voltage are:

Voltage	20.8	volts
Current	8.27	amperes
Torque	101.5	oz-in
Speed	1000	rpm
Input Power	172	watts
Output Power	78	watts
Efficiency	45%	

2.2.2 Brake

An electric dead-man brake inserted between the



Detachment Detail

motor and gear reduction unit brakes the motor to a stop when voltage is removed from the motor and brake. This prevents line from paying out from the winch when the motor is stopped. The brake is made by Electroid Corporation, Model BFSB-35, rated at 24 volts. This was ordered with an unencapsulated coil in order to prevent possible crushing due to entrapped air in the encapsulation at high pressures. The standard cork brake disc was found to permanently compress under the hydrostatic pressure encountered in deep water causing the brake to remain on. A substitute disc of Ryton was found to be unaffected by pressure.

2.2.3 Speed Reducer

A helical gear reducer is mounted between the motor and winch drum which reduces the motor speed by 113.72:1. The unit is a Type R40 manufactured by Eurodrive, Inc.

2.2.4 Turns Counter

A microswitch is mounted on the output shaft of the gear reducer to count turns of the shaft. This information is used in the control unit to control the amount of line payed out and hauled in.

2.2.5 Winch Drum

The instrument line is stored on an aluminum drum having a core diameter of 4½" with 12" flanges. The drum is mounted on a stainless steel shaft coupled to the output of the gear reducer. The shaft bearings, running in water, are plastic. The drum holds up to 300 meters of ¼" line.

2.2.6 Load and Speed Characteristics

The winch is rated for a fifty pound line pull which is approximately equal to the buoyancy of the instrument line net buoyancy. Under this load the ascent speed of the instruments is 14 meters/minute with a descent speed of eight meters/minute. The speed varies from top to bottom of travel dependent upon the number of layers of line on the drum.

3.0 THE POWER SUPPLY

3.1 Main Battery

The main battery which furnishes power to the winch motor, was selected for its high energy density and charge-retaining capability. The battery assembly consists of 12 heavy-duty lead-acid cells, Type KCPSA-13, manufactured by C & D Batteries of Conshohocken, PA. They were originally designed for photovoltaic energy storage.

3.1.1 Physical Description

Each cell measures 6x10 inches by 18 inches in height, and weighs 113 pounds. The total weight of the 12 cells is 1356 lbs. The case is made of transparent thermoplastic polycarbonate, a

high impact material capable of handling high shock and vibration levels without breakage. The weight of the battery allows it to serve as the main ballast for the complete winch and tripod frame assembly. A specially fabricated fiberglass compartment houses the cells in a 3x4 cell series-connected configuration. Polyester resin-coated oak separators prevent movement of the individual cells. A fiberglass cover is gasketed and bolted to the compartment to form a leak-proof seal. The positive and negative terminals are wired to a bulkhead connector at the top of the compartment.

The battery connector is specifically configured to break-away when the top of the tripod is released. A force of approximately 20 pounds is required for separation. A hole between the pins in the receptacle provides internal pressure equalization to the assembly.

In order to prevent electrolyte from being lost due to out-gassing during charge and discharge, the cell caps were removed and replaced with special hollow plastic caps filled with Dynawool hair. oplets of electrolyte that are gas-borne are scrubbed out by the nawool and drop back into the cell.

3.1.2 Electrical Characteristics

The KCPSA-13 is a lead-calcium- .d type battery which is noted for its slow self-discharge characteristic and minimal gas production during discharge. The power density of the battery was increased by specifying a specific gravity of 1.300 as compared to a normal 1.210. Each cell is rated for 675 AH capacity at an eight hour discharge rate at 77°F. The terminal voltage of a fully charged cell is nominally 2.1 volts. The battery is placed on charge when the terminal voltage falls to 1.75 volts, or when the specific gravity decays from 1.300 to 1.275. A Model FR12CE95E ferro-resonant fully automatic charger was purchased from the battery manufacturer, and is designed to charge 12 cells with a total terminal voltage of 24 volts. It operates from 240 volts, single phase, AC power and delivers a maximum current of over 95 amperes, with a 450 to 960 ampere-hour output over a 12 hour charging period. When first turned on, the charge current is approximately 105 amps decreasing to around 80 amps in five minutes and tapering off to a very small current at the end of a 12 hour charge period.

The state-of-charge was monitored during a two year storage period after delivery, and an equalizing charge applied when the specific gravity and terminal voltage reached the low limits, generally every two to four months.

Prior to installation on the winch, the battery was deep-discharged according to the manufacturers recommendations. The battery was discharged at a three hour discharge rate of 165 amps/hr. It was then recharged and placed in service.

3.1.3 Pressure Compensation System

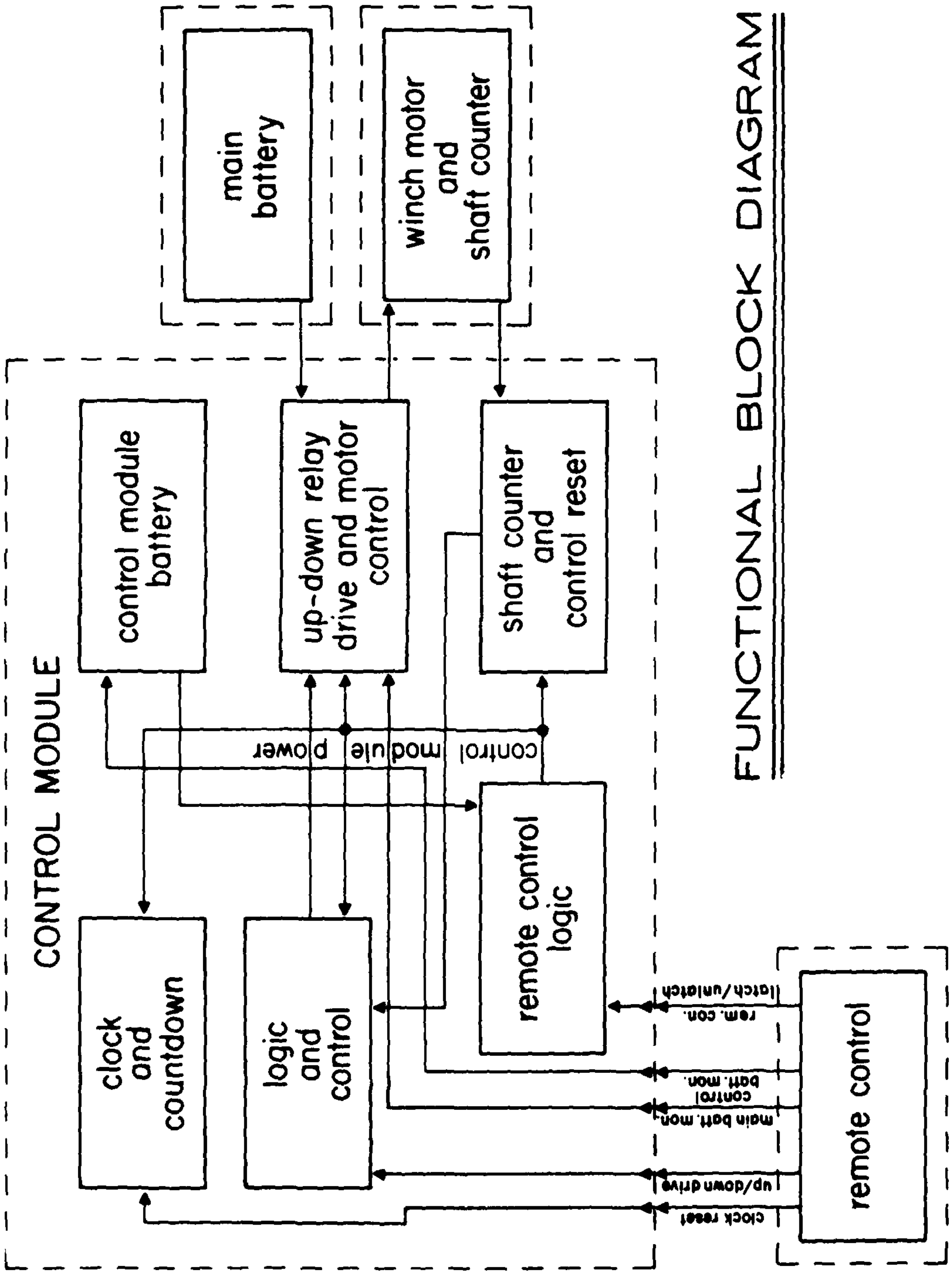
The power supply system operates in pressure equilibrium with the external hydrostatic pressure. The battery compartment is filled with a special oil, Markol 52, which has a high electrical insulation

and will not mix with the battery acid. A fitting is provided in the top of the cover for filling the tank with oil and another to purge out the air. A length of Tygon tubing connects from the fill-fitting to a rubber bladder. With the cells installed in the compartment, the cover sealed on, and the bladder connected, the system including the bladder is completely filled and all possible air purged out of the top vent fitting. The oil fills the cell tops and is in contact with the electrolyte. The battery compartment and bladder hold 43 gallons of oil. The specific gravity is .872 and the volume compressibility due to hydrostatic pressure at 5000 meters (7370 psi) is 2.75% at 35°F. An additional 0.2% volume decrease would result if the system was filled at room temperature (75°F) and deployed in the ocean at 35°F. Thus the total decrease in volume due to hydrostatic pressure and operating ambient temperature would be 2.95% or 1.25 gallons. The bladder is mounted lower than the battery compartment to provide a positive pressure to maintain the compartment full of oil as the volume of oil decreases due to pressure. The resulting pressure due to this head is about 0.13 psi. The bladder volume is about 2.5 gallons, sufficient to maintain the compartment full at all times. Without the bladder the oil shrinkage within the compartment would collapse or allow sea water to enter. A 0.33 psi relief valve located on the top of the compartment relieves any pressure due to outgassing of the batteries, preventing rupture of the case.

A similar separate system is provided for the winch motor and gear box which are mounted in a separate sealed compartment. The gear box output shaft protrudes through a sealed gland in the end of the compartment and drives the winch drum shaft. An external bladder mounted below the compartment is joined to the bottom of the tank with a length of tubing. Fill and bleeder fittings are located on top of the compartment.

4.0 ELECTRONIC CONTROL SYSTEM

Direction of motion of the winch drum and the timing of its periods of operation are determined by an electronic system that utilizes COSMOS integrated circuits mounted on plug-in laminated fiberglass printed wiring boards. The electronics system, shown functionally in Figure 4, can be divided conveniently into four principal sections. The Clock, Logic and Control Section controls the timing and specifies the direction of rotation of the winch. The Shaft Counter and Control Reset Section counts a predetermined number of winch drum rotations, at the end of which a stop and reset signal is sent to the Control Section. The Up-Down Relay Drive and Motor Control Section converts a low level logic voltage into power to drive the winch motor relays. The Remote Control Logic Section and Remote Control Module are interconnected by a removable cable. With the system fully assembled ready for deployment, the Remote Control Module is used to latch power on in the electronics pressure case, reset the internal clock, drive the winch in either direction, furnish terminals for measuring battery voltages, and pre-position the winch prior to deployment. Once the system is powered on, the clock reset, and the drum positioned, the remote control cable can be removed, the connector covered with a dummy plug to seal out water, and the system will sequence itself automatically.


FUNCTIONAL BLOCK DIAGRAM
CONTROL MODULE
main battery
winch motor and shaft counter
control module battery
up-down relay drive and motor control
shaft counter and control reset
control module power
clock and countdown
logic and control
remote control logic
remote control
latch/unlatch
rem. con.
control batt. mon.
main batt. mon.
up/down drive
clock reset

Other features of the Electronic Control Section include a range of cycle time from 15 minutes to six months, a "speed-up" program that can be switched in to allow short test cycles, and a range of winch shaft rotations from one to 999 per "up" or "down" step.

4.1 Clock, Logic, and Control Section

The Clock board is the same as that used in the AMF Vector Averaging Current Meter (VACM). The clock is a Bulova XO-107 crystal oscillator operating at a fundamental frequency of 74.565604 kHz, or a period of 13.411045 microseconds, with binary counter output pulses available from 26.8 microseconds (2^1) to 341 days (2^{22}). For the winch application several outputs are used, between 56 seconds (2^{22}) and 128 hours (2^{35}). A multi-pole, multi-position switch is wired in such a manner that more than one timing interval can be programmed. This is particularly useful in that a "speed-up" program can be incorporated having a cycle time in the order of 15 to 30 minutes. Such a feature saves time when testing the system compared to a typical operational period of 72 hours. Power application and control functions can be exercised either from internal controls when the electronic package is removed from the case, or from the remote control box when the system is fully assembled ready for deployment. The system is placed in operation by turning on the power switch and pressing the internal CLOCK RESET switch, or a similar switch on the Remote Control Box. The first operation after that, predetermined by the wiring of the back-plane switch, is the actuation by the clock On-Down function starting the winch drum. The initial direction of the drum will have been determined by the wiring polarity of the winch motor. As he crum turns, a microswitch mounted on the motor gear box output shaft closes once for each rotation of the shaft, and the closure is sensed by the input one-shot multivibrator on the Shaft Counter and Control Reset Board. Any accumulated count from one to 999 can be pre-wired into the counters, and the result is an output pulse fed back to the On-Down flip-flop to reset it, stopping the winch. A waiting period is then established which inhibits further operation until another clock pulse occurs, allowing the Up-On signal to be clocked through to start the winch in the opposite direction. As in the Down phase, an Up counter counts the rotations of the shaft, sending an output signal after a predetermined number of counts, resetting the Up-On logic circuit. The Up sequence repeats itself in steps, and while doing so the Down counter accumulates the count. When the total reaches the same as the original Down count, this counter sends a reset signal which stops the winch. At the end of another waiting period the clock sends an output pulse to the Down logic channel and a reset pulse to itself. The clock is now reset to time zero and the whole sequence is re-initiated. Auto sequencing continues until the operator turns off the Internal Clock and Logic Power switch or latches off the power from the Remote Control Box. For test purposes the operator can manually operate the system by manipulating the Manual Start switch on the main frame, or the Down Drive or Up Drive switches on the Remote Control Box.

Rewiring the back plane between the Clock and Logic and Control boards can produce a wide variety of operational and test programs.

4.2 Shaft Counter and Control Reset Section

Some of the functions of this section were described in paragraph 4.1 above in order to establish continuity. The shaft counter and control reset receives its clock pulses from the shaft counter micro-switch through the cabling from the motor compartment. A filter eliminates switch contact bounce noise and prevents false counts from occurring. In the speed-up (test) mode, selected counter output pulses are wired to a coincidence AND gate; in the operational mode, output pulses are taken from the same counters and wired to another gate producing coincidence at a higher count. The Up counter consists of a single stage because fewer counts are needed to produce discrete steps in the Up sequence.

4.3 Motor Relay Driver

Drive signals for the winch motor originate in the Electronic Control Section in the form of a low-level voltage, with little current capability. This voltage is amplified in the Motor Relay Driver circuitry to a level sufficient to energize the coil of a heavy duty relay. The contacts of the relay, rated at 10 amps, complete the circuit between the main battery and the winch drive motor.

The relay drive circuit consists of two parallel amplifiers which are turned on by signals from the Control Section. The output transistor collectors are in series with the relay coils and provide sufficient current to actuate the relays. Motor current is typically two to eight amps, depending on the load. One amplifier actuates the Down-On relay, while the other amplifier activates the Up-On relay.

4.4 Remote Control Section

The Remote Control Box is connected to the electronics pressure case by means of a portable cable which terminates in a molded rubber cable connector. Connections are made from the Remote Control Box through the cable to the Logic and Control Board and to the Shaft Counter and Control Reset sections. The Remote Control Box performs several functions. It has its own ON-OFF switch that completes a circuit to a 9-volt battery in the box itself and furnishes power to logic circuitry which operates a latching relay on the main frame. The contacts of the latching relay apply power from the internal battery to the electronics assembly. Another switch on the Remote Control Box is used to reset the clock. Two other switches allow manual operation of the winch when testing or prepositioning the drum for deployment. Jacks are provided to permit a voltmeter to be plugged into the box to measure main battery and internal electronics battery voltages. When the system is latched OFF the meter will read the internal battery (12 volts), and when latched ON will read the main battery (24 volts). With power latched ON, the clock and control unit reset and the drum positioned, the remote control cable can be unplugged and the cable jack covered with a dummy plug to seal out water, after which the system will sequence itself automatically.

5.0 STATIC ANALYSIS OF INSTRUMENT LINE BEHAVIOR

A static analysis of the system was made to determine the inclination and dip of the top instrument when extended fully (100 m).

A computer program (NOYFB) was used to predict these quantities for current speeds of 0, 5, 15 and 30 cm/sec from top to bottom. The instrument line was assumed to have 3-17" glass balls at the top with a VACM current meter and an Oceanographic Instrument Systems Model 3000 acoustic transponder under it. The instrument line is 100 m of ¼" Kevlar rope in a wire rope construction. A line tension of 65 lbs was assumed at the winch. The inclination from the vertical and dip of the current meter as a function of current speed were:

Current Speed cm/sec	Inclination Deg.	Dip m
0	0	0
5	0.3	0
15	2.4	0.2
30	3.8	9.5

6.0 SEPARATION AND RECOVERY CONCEPT

The system is recovered by firing the acoustic release which separates the top portion of the tripod from the lower portion. The buoyancy of the top section, provided by six glass spheres attached to the frame plus the fifty pounds provided by the instrument line flotation, then permit the upper section, containing the instrument line, winch control electronics and the acoustic release, to come to the surface. The lower portion of the tripod along with the batteries are left on the bottom. This expenditure of the battery supply must be considered in cost-benefit terms for any particular experiment. For instance, daily samples over a period of one year might well be worth this expenditure. For shallow water experiments ($<$500 m) it appears feasible to bring a separate light line which is attached to the lower section, to the surface with the upper portion of the tripod for subsequent recovery of the batteries. This can be done by mounting an inside-payout spool of ¼" Kevlar line on the lower section with the inner end attached to the upper tripod section.

A transponder mounted below the current meter on the instrument line is used to initially locate the tripod, confirm release and aid in location after surfacing. The complete winch system sinks at a rate of about 1.8 m/sec after launch. The upper portion ascends about one m/sec depending upon the number and type of instruments attached to the instrument line.

ACKNOWLEDGEMENTS

The authors wish to thank Messrs Patrick O'Malley and Matthew Gould for the construction of the winch assembly. We appreciate the opportunity for tests at sea provided by Drs. Charles Hollister and Albert Williams under the HEBBLE program. We are indebted to Mr. Thomas B. Aldrich for excellent graphics support and Mrs. Charlotte Muzzey for secretarial services.

LIST OF FIGURES

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. WHOI-84-12	2.	3. Recipient's Accession No.

4. Title and Subtitle
Bottom-Mounted Profiling Winch

5. Report Date
March 1984

6.

7. Author(s)
R. G. Walden and C. W. Collins, Jr.

8. Performing Organization Rept. No.
WHOI-84-12

9. Performing Organization Name and Address
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C) N00014-82-C-0019
(G)

12. Sponsoring Organization Name and Address
Office of Naval Research
Environmental Sciences Directorate
Arlington, Virginia 22217

13. Type of Report & Period Covered
Technical

14.

15. Supplementary Notes
This report should be cited as: Woods Hole Oceanog. Inst. Tech. Rept. WHOI-84-12.

16. Abstract (Limit: 200 words)

A winch has been developed which can be free-dropped to the ocean bottom in full ocean depths. The winch is powered by self-contained batteries and can be programmed to cycle self-recording instruments from close to the bottom to 100 meters above the bottom continuously or in steps. A typical scenario is envisioned as one complete cycle per day for one year with the instruments pausing each five meters for two minutes while measurements of current, temperature and conductivity are made. The upper section of the tripod contains the winch and instrumentation and is recovered by sending an acoustic command to a release mechanism allowing it to come to the surface.

17. Document Analysis a. Descriptors

1. Winch
2. Profiler
3. Benthic

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement:	19. Security Class (This Report)	21. No. of Pages
Approved for public release; distribution unlimited.	UNCLASSIFIED	13
	20. Security Class (This Page)	22. Price

(See ANSI–Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4–77)
(Formerly NTIS–35)
Department of Commerce

MANDATORY DISTRIBUTION LIST

FOR UNCLASSIFIED TECHNICAL REPORTS, REPRINTS, AND FINAL REPORTS PUBLISHED BY OCEANOGRAPHIC CONTRACTORS OF THE OCEAN SCIENCE AND TECHNOLOGY DIVISION OF THE OFFICE OF NAVAL RESEARCH

(Revised October 1983)

1 Deputy Under Secretary of Defense
(Research and Advanced Technology)
Military Assistant for Environmental Science
Room 3D129
Washington, DC 20301

Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

3 Attn: (Code applicable to Program) *

1 Attn: Code 420C

2 Attn: Code 102C

Commanding Officer
Naval Research Laboratory
Washington, DC 20375

6 Attn: Library Code 2627

1 Attn: Library Code 2620, Mr. Peter Imhof

12 Defense Technical Information Center
Cameron Station
Alexandria, VA 22314
Attn: DCA

Commander
Naval Oceanographic Office
NSTL Station
Bay St. Louis, MS 39522

1 Attn: Code 8100

1 Attn: Code 6000

1 Attn: Code 3300

1 NODC/NOAA
Code D781
Wisconsin Avenue, N.W.
Washington, DC 20235

* Applicable Codes: 422 (PO); 422CB (Chem/Bio); 422CS (Coastal); 425 (G&G); 425AR (Arctic); 421 (OE); 421SP (Ships); 425OA (Ocean Acoustics); 425UA (Underwater Acoustics)